TECHNOLOGICAL MOMENTUM IN HISTORY: HYDROGENATION IN GERMANY 1898-1933

IN DECEMBER 1933, I. G. FARBEN, THE GIANT GERMAN CHEMICAL FIRM, contracted to supply National Socialist Germany with synthetic gasoline. This promised to affect Germany's great-power status for Germany depended almost entirely upon gasoline imports in a world where machines of peace and of war consumed enormous quantities of the fuel. Fourteen years later at the Nuremberg Military Tribunals the prosecution argued that the contract was evidence of a conspiratorial alliance between the Nazis and Farben to prepare wars of aggression.[1]

The effort here is not to refute the conspiracy charge (the judges at Nuremberg did not find the charge proven), but to shift the emphasis from the conspiracy thesis to a consideration of technological momentum, a compelling dynamic force usually ignored by historians. Publicity given to the conspiracy charge and to Farben's involvement in slave labour and spoliation during the war have tended to overshadow less emotion-laden issues and to obscure historical factors such as technological momentum.

In order to define technological momentum, and consider its explanatory power, the essay has been structured in a somewhat unconventional way. The chronological method has been used to convey the characteristics, dynamism, and persistence of technological momentum. When the narrative reaches 1930 increasing use is made of analysis to compare technological momentum with alternative explanations for Farben's early relations with National Socialism. These alternative explanations, consistent with the conspiracy thesis

[1] The charge is specified under Count One ("Participation in the Planning, Preparation, Initiation, and Waging of Wars of Aggression and Invasions of Other Countries") of the indictment found in *Trials of the War Criminals before the Nürnberg Military Tribunals Under Control Council Law No. 10* (Washington, U.S. Govt. Printing Office, 1953), vii, pp. 16, 19 (esp. paras. 2, 7, and 18). Twenty-three high officials of I. G. Farben, mostly members of the *Vorstand* (managing board), were charged with war crimes and tried before the Nuremberg Military Tribunals, as were other groups from industry and the professions. The trial of the Farben officials was Case VI, sometimes referred to as the Krauch Case — Krauch was the principal defendant. A part of the record of this case is published in volumes vii and viii of the fifteen volumes in the series. Cited hereafter as *Trials of the War Criminals* ...

advanced at Nuremberg, have been introduced when they seem most plausible.

The conclusions drawn by the author must be exasperatingly tentative because Farben, shortly before the Allied occupation, destroyed fifteen tons of documents, some of which would have been helpful in establishing the situations surrounding the decisions of Farben and in investigating the firm's motivations.[2] Despite this handicap however, enough evidence survives to define the momentum and to suggest its force. To describe the build-up of the force and its interaction with other historical forces the story begins, not with politicians and businessmen preoccupied with power and profit, but with a scientist concerned about the world food supply.

In 1898 at the Bristol meeting of the British Association for the Advancement of Science, Sir William Crookes said in his presidential address, "my chief subject is of interest to the whole world — to every race — to every human being". "England and all civilized nations", he continued, "stand in deadly peril of not having enough to eat ... land is a limited quantity ... it is the chemist who must come to the rescue of threatened communities". He calculated that, if all the wheat-growing countries added the utmost to their area of cultivation, the increased yield could keep pace with the increase of population for only about thirty years; the only solution seemed to be increased yield per acre. To achieve this, the supply of nitrogen fertilizer had to be increased. Because the world's chief natural source, Chilean nitrates, would probably be depleted in thirty years, Crookes called upon the chemist and the laboratory to supplement nature with technology.[3]

Crookes's warning applied especially to Germany. Dependent upon intensive use of its soil, Germany was the world's largest importer of Chilean nitrates. It obtained 50 per cent of its nitrogen from Chile and the remainder as a by-product of the manufacture of coke and gas from coal.[4] Germany produced more nitrogen as a by-product (ammonium sulphate) than any other power, but it could not

[2] Among the fifteen tons of files destroyed were the minutes of the meetings of the board of directors *(Aufsichtsrat)* and managing board *(Vorstand)* of Farben. *Trials of the War Criminals ...*, vii, pp. 447 ff.

[3] Sir William Crookes, "Presidential Address", *Report of the Sixty-Eighth Meeting of the British Association for the Advancement of Science* (London, John Murray, 1899), pp. 3-38.

[4] Nitrate Division, Ordnance Office, War Department: *Report on the Fixation and Utilization of Nitrogen* (Washington, GPO, 1922), p. 43. In 1913 Germany produced 124,664 net tons of nitrogen as a by-product of the manufacture of coke and gas, and imported 133,179 net tons of nitrogen in the form of Chilean nitrate.

increase the production of metallurgical coke and gas simply to increase the supply of nitrogen. Germany, as Crookes advocated, turned to the chemist and the laboratory. With notable success German academic and industrial chemists had earlier made such a move by creating coal tar dyes as substitutes for and improvements upon natural dyes.[5] As the Nobel Prize-winning German chemist Fritz Haber observed, Germany had reached the stage of development where it depended more for resources upon science and technology and less upon nature. Unlike a young nation sparsely settled, Germany could not draw heavily upon resources created in the past and stored by nature.[6]

Crookes emphasized that the atmosphere contained enough free nitrogen to supply man's immediate and anticipated needs, for every square yard of the earth's surface has about seven tons of nitrogen gas pressing down on it. The problem was to fix this nitrogen, or combine it, in a usable form. The most famous fixation process developed before World War I was the Haber-Bosch process which combined nitrogen with hydrogen to produce synthetic ammonia.

The process bore the name of the chemist, Haber (1868-1934) and the engineer, Carl Bosch (1874-1940), who also won the Nobel Prize. Haber, a physical chemist and professor at Karlsruhe, drew upon the rapid advances made in chemical thermodynamics by Professor Walther Nernst (1861-1941) and others.[7] By 1909 Haber proved on a laboratory scale the feasibility of fixation by combining atmospheric nitrogen with hydrogen under conditions of extremely high pressure and temperature, with the aid of a catalyst to spur the reaction. Bosch, an engineer at the *Badische Anilin- und Soda-Fabrik* (BASF), who was experienced in metallurgy, machine and process design, drew upon the industrial resources of BASF, one of Germany's pioneer chemical enterprises, to scale-up the process to the pilot-plant level. This was a demanding task because Bosch had to use materials and structures that withstood extreme operating conditions. In 1913

[5] John Beer, *The Emergence of the German Dye Industry* (Urbana, Ill., Univ. of Illinois Press, 1959), pp. 70-93; Ludwig F. Haber, *The Chemical Industry During the Nineteenth Century: A Study of the Economic Aspect of Applied Chemistry in Europe and North America* (Oxford, 1958), pp. 128-9.

[6] Fritz Haber, "Die deutsche Chemie in den letzten 10 Jahren", in *Aus Leben und Beruf: Aufsätze, Reden, Vorträge* (Berlin, Springer, 1927), p. 8.

[7] The research and development work of Haber, and, later, Bosch is justly celebrated, but their dependence on earlier scientific research should be stressed. They and their colleagues involved in industrial development of this and later hydrogenation processes drew upon pioneer work in chemical thermodynamics. Aaron J. Ihde, *The Development of Modern Chemistry* (New York, Harper & Row, 1964), pp. 531-4.

they put a small Haber-Bosch plant in production at Oppau near Ludwigshafen, the home of BASF.[8]

If there had been no world war and if trade had remained reasonably free, the production of nitrogen compounds by fixation would probably have increased gradually over two or three decades as the supply of Chilean nitrates decreased. The Haber-Bosch method would have competed with other recently developed fixation processes, such as the calcium cyanamide and the electric arc processes, to supply the market during this period of transition.[9] The war, however, disrupted this gradual transition and stimulated the enormous and rapid growth of facilities to produce Haber-Bosch synthetic ammonia. The allied blockade cut off Germany's supply of Chilean nitrates while the needs of war increased the demand. Nitrogen was needed not only for fertilizer but also for the production of all explosives. As the war became one of attrition Germany's predicament worsened.[10] In the summer of 1915, when the limits of the manufacture of nitrogen as a by-product were reached and the stockpiles of nitrates exhausted, Germany turned to the rapidly expanding Haber-Bosch process to help meet the demand for munitions and for fertilizer. The Oppau plant was expanded from an estimated annual capacity of 7,000 metric tons of nitrogen in 1913 to 100,000 tons early in the war. A mammoth new Haber-Bosch plant was constructed at Leuna near Merseberg. Begun in the spring of 1916 and operating a year later, the plant reached three-

[8] For a description of the research and development work of Haber and Bosch see translations of selections from Robert Le Rossignol, "Zur Geschichte der Herstellung des synthetischen Ammoniaks", *Die Naturwissenschaften,* xvi (1928), p. 1070; Carl Bosch, "Über die Entwicklung der chemischen Hochdrucktechnik bei dem Aufbau der neuen Ammoniakindustrie", Nobel Address of 1932, in Friedrich Klemm, *A History of Western Technology,* transl. by Dorothea Singer (New York, Scribner's, 1959), pp. 364-70.

[9] For a full description of the three fixation processes including the Haber-Bosch, see J. R. Partington and L. H. Parker, *The Nitrogen Industry* (New York, 1923); and Nitrate Division, Ordnance Office, War Dept.: *Report on the Fixation and Utilization of Nitrogen* (Washington, D.C., 1922). The book by Partington and Parker concentrates on the German developments; the second volume discusses the U.S. efforts.

[10] German chemists and industrialists have cited the small capacity of the nitgrogen fixation plants at the time of the outbreak of the war as confutation of the hypothesis that Germany started the war when she had an assured domestic supply of nitrogen. See, for example, Alwin Mittasch, *Geschichte der Ammoniaksynthese* (Weinheim, Verlag Chemie, 1951), p. 181 and *passim*; Fritz Haber, "Die deutsche Chemie in den letzten 10 Jahren", *op. cit.,* n. 6 above, p. 13; Carl Duisberg, "Die Herstellung von synthetischem Saltpeter . . .", in "Die Tätigkeit der Chemischen Industrie während des Krieges", 1916 (a typescript in the *Deutsches Museum,* Munich).

quarters of its intended 200,000 ton capacity by the end of the war.[11] By then Germany had the industrial capacity to produce about 535,000 tons of nitrogen annually: 250,000 tons by the Haber-Bosch method, 120,000 tons by the cyanamide process, and 165,000 tons as by-product nitrogen; and in 1918 about 490,000 tons were actually produced. The Haber-Bosch capacity in 1918 equalled the total consumption of nitrogen in Germany from all sources in 1913.[12]

The dramatic development of the Haber-Bosch process and plant during World War I is comparable to that of other great wartime technological innovations such as the Manhattan and the Radiation Laboratory (radar) projects in the U.S.A., and the Peenemünde (rocket) project in Germany during World War II. The Haber-Bosch project, like these others, provided a common experience of great educational value for the engineers and scientists. Bosch supervised the team that designed and constructed the plant at Leuna, and all participants became expert in the new and complex field of industrial chemistry. It gave them a problem-solving technique and a technological style that carried over after the war. They had acquired characteristics that would mark their future work.

What had they learned from Oppau and Leuna that gave them a particular competence, a creative potential? The chemists and engineers acquired experience with processes taking place under extraordinary conditions. The reaction, the combining of hydrogen and nitrogen, required an operating pressure of about 200 atmospheres and a temperature of 400-500°C. The discovery of a suitable catalyst to spur the reaction had been a major problem and as a result the BASF staff became expert in catalytic chemistry. Furthermore, they learned how to produce economically large quantities of hydrogen. In short, the research and development, and the subsequent industrialization of the Haber-Bosch process gave BASF chemists and engineers great potential in a complex new technology: high-pressure, high-temperature, catalytic hydrogenation.

Not only had the engineers and chemists acquired an understanding of hydrogenation, they had also learned to design the equipment which could be used in other hydrogenation processes. Outstanding among the apparatus were the large double-jacketed reaction or contact ovens capable of withstanding corrosion and extremes of pressure and temperature; compressors of previously unattained

[11] The construction of Oppau and Leuna are discussed in Karl Holdermann, *Im Banne der Chemie: Carl Bosch, Leben und Werk* (Dusseldorf, Econ-Verlag, 1960), pp. 101-3, 147-52; and Mittasch, *Ammoniaksynthese*, pp. 136-41.

[12] Nitrate Division: *Report on the Fixation . . . , op. cit.*, n. 4 above, pp. 43, 57.

horsepower; gas circulation pumps of hitherto unachieved capacity; and monitoring instruments providing a unique combination of sensitivity and ruggedness. The knowledge and the tools gave the engineers and chemists a creative potential, and their exhilarating wartime successes and confident attitudes generated a desire to attack similar problems in the future. Young engineers and chemists fresh from the universities and technical colleges might rise rapidly if BASF explored new fields of research and development; if, however, the enterprise maintained its lead in hydrogenation and invested substantial resources here, then the experienced men held an advantage. The commitment of the experienced contributed to the momentum that carried hydrogenation technology into peacetime.

Commitment of the BASF management to the technology also provided momentum. In developing and expanding the Haber-Bosch process the company had invested its own and government funds into vastly productive technology. That part of the plant built with Reich funds passed into company ownership after the war. This equipment included transportation and material-handling facilities for the immense amount of coal used as fuel and as a chemical in the process. Large heating plants had been built to supply the steam and heat needed for the process. In addition, sub-plants for the production of hydrogen gas had been constructed. This production capacity might be fully occupied after the war in satisfying Germany's nitrogen needs in agriculture and industry but, if additional applications of hydrogenation could be found, then these might use some of the existing production facilities if the market for nitrogen compounds should prove inadequate.[13]

BASF continued to support research in hydrogenation for another reason. The company, like other electrical and chemical concerns in Germany, had a large number of scientists and engineers in its management who took especial interest in decisions about research and development. Among them were chemists and engineers who had pioneered in the research and development of Haber-Bosch and took a proprietary interest in hydrogenation. Their leader was Carl Bosch who became the foremost decision-maker for BASF, and then for *I. G. Farbenindustrie* of which BASF was a prime constituent.

[13] The post-war problem of utilizing expanded capacity, both equipment and personnel, was not limited to I. G. Farben. In America the du Pont Company's newly formed Excess Plant Utilization Division concentrated upon finding use for smokeless-powder facilities. The company also sought diversification in the complex processes of nitrocellulose technology. Alfred D. Chandler, *Strategy and Structure: Chapters in the History of the Industrial Enterprise* (Garden City, N.Y., Doubleday, 1966), pp. 101-3.

Named chairman of the managing board of BASF in 1919 and then of I. G. Farben after BASF merged with other large German chemical firms in 1925, Bosch was in a strategic position to direct the research and development programmes of these enterprises. Time proved him an effective proponent of new hydrogenation projects.

Also important as a transmitter of the acquired knowledge was Alwin Mittasch (1869-1953). After obtaining his doctorate at Leipzig with work on catalytic chemistry, Mittasch joined BASF in 1904. He not only worked closely with Bosch on ammonia synthesis, but also developed a process for the oxidation of ammonia which yielded sodium nitrate, needed during the war for the manufacture of explosives.[14] During the war he became director of the *Ammoniak Laboratorium,* later a major laboratory facility of BASF-I. G. Farben. Bosch and Mittasch, therefore, maintained the momentum built up in the new chemistry during the war through the institutions they headed.

Among the younger engineers and chemists who became involved in the field during the war, Carl Krauch (1887-) played a major rôle in its post-war history.[15] Krauch, a chemist, joined BASF in 1912 and Mittasch's laboratory staff in 1913. Bosch later named the promising young man technical director at the newly erected Leuna work and in 1922 Krauch became manager. He rode the crest of the wave of second generation workers in the new field. Like Bosch earlier, he proved a strong advocate of hydrogenation. Possessing remarkable records of wartime achievement, these men faced a new and less friendly post-war environment in which they had to function and their new chemistry had to flourish.

The creative potential of the chemists and the engineers, the vested interest in the plant, and the proprietary attitude toward hydrogenation of technical men in managerial positions all contributed to the momentum. This momentum had two major components, the drive to produce and the drive to create. To utilize the productive capacity of the plant was one postwar problem; to find expression for the creativity of the chemists and the engineers another. The second of

[14] For a description of the process see Alwin Mittasch, *Saltpetersäure aus Ammoniak* (Weinheim, Verlag Chemie, 1953).

[15] Affidavit of Prof. Carl Krauch, Doc. No. NI-8525, Office of Counsel for War Crimes; and affidavit of Ernst A. Strauss, Doc. No. NI-5020, Office of Chief of Counsel for War Crimes. These affidavits were obtained for the Nuremberg Military Tribunals, Oct. 1946 to April 1949. The author used the mimeographed record of the trial at the Harvard University Library, and also the incomplete file at the *Institut für Zeitgeschichte* in Munich. Cited hereafter as: Nuremberg Military Tribunals.

the two proved the more challenging and had the more fateful consequences in history.

For several years adaptation and modification of the Haber-Bosch process absorbed the creative energies of the chemists and engineers. They improved the catalyst and the apparatus, and refined the process. Carl Bosch supported scientific research in plant nutrition and nitrogen fertilizers. The market also absorbed the productive capacity. Government subsidies lowered the price of nitrogen fertilizers for the German farmer, and the increased market necessitated enlarged and improved plants. Oppau and Leuna expanded production from 1920 when together they produced only 122,000 tons of nitrogen until 1928-9 when production reached 635,000 tons.[16] Adaptation and expansion of wartime production facilities for the peacetime market did not long provide sufficient scope, however, for the creative abilities of BASF chemists and engineers. If BASF had only refined and expanded production, her research and development personnel would have been unemployed.

Their creative potential did find expression, however, in a new hydrogenation process. In 1923, after several years of research and development, BASF began at Ludwigshafen-Oppau the large-scale production of synthetic methanol (wood alcohol), a chemical with a peacetime market. The new process was under the direction of Krauch. This process was similar to the ammonia synthesis in many particulars and clearly manifested the carry-over from the earlier process. Ammonia synthesis was in essence the combination of hydrogen with nitrogen; methanol synthesis was the hydrogenation of carbon monoxide gas. Both processes took place under similar temperature and pressure conditions, and therefore required similar ovens, compressors, and circulation pumps. Reserve apparatus at Leuna was adapted for the new process.[17]

A significant difference was in the catalyst: the ammonia synthesis used a metallic catalyst, the methanol an oxidic. The newer catalyst not only accelerated the reaction but also directed it towards the desired end product. The uncontrolled process could have taken several

[16] Holdermann, *Bosch*, pp. 180, 220-8.

[17] *Die Katalytische Druckhydrierung von Kohlen, Teeren und Olen: Aus den Arbeiten der Hochdruckversuche: 1924 BASF, 1925-1945 I. G. Farbenindustrie A.G.*, p. 22. This monograph was prepared shortly after World War II by BASF and I. G. Farben scientists and engineers under the general direction of the occupation authorities. A mimeographed copy is in the *Firmenarchiv* BASF, Ludwigshafen, and was loaned to the author. Hereafter cited as *Die Katalytische Druckhydrierung*. The BASF archives supplied few sources because the relevant materials had been destroyed by Farben or taken by occupation authorities for the purposes of the war crimes trials.

directions. The additional characteristic of the new catalyst broadened the horizons of hydrogenation because complex processes needed a direction-giving or selective catalyst to assume technological-commercial significance.

Now having two major achievements in hydrogenation to its credit, there was no doubt of BASF's unique excellence and potential. This potential was further institutionalized by the growth of the *Ammoniak Laboratorium* at Oppau during the years 1924-29, and the creation of a special section, the *Hochdruckversuche* (High Pressure Laboratory) responsible for research and development in high pressure processes.[18] The High Pressure Laboratory, headed by Dr. Matthias Pier (1882-1965), was attached to the Oppau ammonia works managed by Carl Krauch. By 1928 this laboratory employed seventy persons with academic degrees (forty-six chemists and twenty-four engineers); academics attached to other laboratories and departments also worked on its projects.[19] Pier had had considerable experience in the new field. He, like Bosch, Mittasch, Krauch and others, had early become involved with ammonia synthesis. In 1920, after having carried on researches elsewhere with catalysts for the process, he joined the *Ammoniak Laboratorium* at BASF and played a leading rôle in the development of methanol synthesis. Because of his extensive experience and his especial competence in the discovery and development of new catalytic agents, Pier was well suited to direct researches on the next problem given to the High Pressure Laboratory.[20]

The new problem generated one of the major research and development projects of the century. The objective was to create synthetic gasoline from coal by hydrogenation.[21] The concept was

[18] "Geschichte des Ammoniaklaboratorium", a typescript in *Firmenarchiv* BASF Ludwigshafen which characterizes the development of the laboratory between 1924 and 1929 as a "great upswing", p. 6. The tasks of the *Hochdruckversuche* are listed in *Die Katalytische Druckhydrierung*, pp. 14 ff.

[19] Information by letter to the author from BASF *Firmenarchiv*, Ludwigshafen, 1 Oct. 1965.

[20] "Zur Entwicklung der grosstechnischen Hydrierverfahren: Matthias Pier zum 70 Geburtstag", *Angewandte Chemie*, lxiv (1952), pp. 407-8.

[21] Coal hydrogenation had an extensive laboratory research history preceding the development and commercialization by BASF-I. G. Farben. Outstanding among the German scientists doing research in coal hydrogenation between 1910 and 1925 was Friedrich Bergius (1884-1949) whose coal liquification patents BASF acquired. Franz Fischer (1877-1947) began after World War I the indirect transformation of coal into liquid fuel. Fischer and his colleague, Ernst Tropsch, later patented the low pressure, low temperature process for making synthetic fuel. The Fischer-Tropsch process was commercialized in the 1930s by *Ruhrchemie A.G.*, an enterprise of the soft coal producers. See Arthur Schweitzer, "Business Policy in a Dictatorship", *Business History Review*, xxxviii (1964), pp. 426-33; and Schweitzer's *Big Business in the Third Reich* (Bloomington, Indiana University Press, 1964), for post-1933 relations between business, politics and — to a lesser extent — technology.

as bold as that of nitrogen fixation, and the scientific and technological challenge, the absorption of technological creativity, proved greater. The decisions made by BASF between 1924 and 1926 to develop the third great process in the field resulted from the momentum of hydrogenation technology interacting with other factors, political and economic. Several factors external to BASF affected the market, and others within the enterprise affected cost.

Among the external factors was the revolution in transportation brought about by the internal combustion engine. The most obvious manifestation of this revolution was the dramatic growth of the American automobile industry. Between 1920 and 1923 annual production of passenger cars in the United States increased from about two million to three-and-one-half million. The automobile industry stimulated the production of petroleum, and the United States led the world in this field in the 1920s. The production of automobiles and of petroleum greatly stimulated an entire system of technologies that together might be called the automobile production and use system.

By contrast, automobile and petroleum production in Germany in the 1920s was small. In 1925 Germany produced only about 40,000 passenger cars and in 1928 slightly over 100,000. Her total production of crude oil between 1857 and 1933 placed her behind the thirteen major producers and left her categorized with the "rest of the world" which produced only one per cent of the total.[21] Because of her small automobile and petroleum production, Germany was not taking part in the internal combustion engine revolution. For a nation that had been a leader in the pre-war "second industrial revolution" involving steel and electricity, the situation was humiliating and alarming: alarming, because the retarded automobile production and use system not only hurt the total economy, but also endangered the great power status of Germany. In peace and in war nations depended increasingly upon motorized transportation.

While Germany could expect to raise domestic production of automobiles, petroleum production was an entirely different matter. Within her borders she had steel and other materials for making automobiles (with the major exception of rubber), but she did not have petroleum for fuel. Germany's position in a mechanized world would

[21] *Statistisches Jahrbuch für das Deutsche Reich 1931*, p. 113. After analysing the state of the German automobile market in 1929, Detroit experts decided that it was comparable with that of the American in 1911: Alfred P. Sloan, Jr., *My Years with General Motors* (New York, 1965), p. 325.

be extremely weak if she were dependent upon fuel imports controlled at the source or *en route* by foreign powers. This economic and political problem made it likely that the government would look with sympathy upon any ingenious plan to provide Germany with domestic supplies of internal combustion engine fuel.

Germany did not have major petroleum deposits nor were there favourable prospects for discovering new ones. On the other hand, she possessed large coal deposits and ranked second only to the United States in mining. Between 1924 and 1933 Germany produced about twenty per cent of the world total of coal and about seventy-five per cent of the world total of lignite (brown coal).[23] If coal, especially brown coal, could be converted to gasoline for internal combustion engines, the possibility of Germany's regaining her economic and political position among the great world powers would improve. The opportunity for Germany became even greater as experts publicized predictions that the world's known supply of petroleum might be depleted in a few decades and that the discovery of large new fields was unlikely.[24] Then Germany, with a gasoline developed from coal, would have a decided advantage.

Her shortage of foreign exchange during the inter-war period also favoured the development of coal hydrogenation.[25] As use of the internal combustion engine in Germany increased, the importation of petroleum drained the limited supply of exchange. This heightened the interest of the government in supporting a programme for developing domestic fuels. The expenditure of foreign exchange increased further because of the necessity of importing natural rubber needed for automobile tyres.[26] The shortage of foreign exchange,

[23] David Brownlie, "Survey of World Energy Production", *Engineering*, cxl (1935), pp. 133-5 176.

[24] The Federal Oil Conservation Board was established by President Coolidge on the assumption that there was danger of a future shortage in oil: see Coolidge letter in A. Williamson, R. Andreano, A. Daum, and G. Klose, *The American Petroleum Industry: The Age of Energy 1899-1959* (Evanston, Northwestern University Press, 1963), pp. 311-12. The Federal Oil Conservation Board in 1926 found that the least hopeful authorities estimated the total known reserves of oil in the United States as not more than a seven-year supply: Frank A. Howard, *Buna Rubber: The Birth of an Industry* (New York, D. Van Nostrand, 1947), p. 16.

[25] "Die Hydrierung und ihre wirtschaftliche Bedeutung", *Petroleum*, xxvii (1931), p. 6. (This article probably originated with I. G. Farben.) Nitrogen fixation after the war saved Germany at least 200 million marks yearly that would have been paid for imported Chilean saltpetre: Holdermann, *Bosch*, p. 180.

[26] For the development of synthetic rubber (Buna) in the 1930s see Wilhelm Treue, *Gummi in Deutschland* (Munich, F. Bruckmann, 1955), pp. 256-83 *passim*.

the increased use of automobiles, and the traditional interest of Germany in having world power status, all helped persuade Carl Bosch that there would be a market for synthetic gasoline in Germany.[27] He probably foresaw tariff protection from the government if needed.

In view of the ultimate contribution that the synthetic gasoline made to rearmament and war under the National Socialists, the question arises whether Bosch and the Farben directors also took into consideration a future military market for their product. The BASF men who had supplied Germany with vital nitrogen during the blockade of the previous war could hardly have been oblivious to the rôle synthetic gasoline could play in economic mobilization and war.[28] Yet, in 1926, the Ministry of Defence, because of Germany's disarmed status, was in no position to support substantially or guarantee a market for a mammoth project scheduled to reach full production within a few years. Anticipation of a military market could certainly have been a consideration of the Farben decision makers, but was probably a minor one for men motivated by practical technological and economic considerations and unaccustomed to invest heavily in highly speculative markets dependent upon a dramatic shift in the political and international climate.[29]

Bosch, who was primarily responsible for the BASF decision to embark upon the project, not only analysed external market factors but also internal cost factors. His deep knowledge of engineering economics encouraged him to introduce new processes that would more fully utilize existing plant capacity. Bosch saw the opportunity to utilize existing nitrogen fixation equipment at Leuna by introducing the hydrogenation of coal.[30] Leuna, for example, had heavily capitalized facilities for making hydrogen used in fixation. Therefore

[27] Carl Bosch, "Erdöl und synthetisches Benzin", *Petroleum*, xxix (1933), pp. 1-2.

[28] At least one historian believes that it is beyond question that Farben embarked upon the project as a preparation for war: Gisela Kahl, "Zu den Kriegsvorbereitungen und der Kriegsdurchführung des IG-Farben-Konzerns in zwei Weltkriegen", *Informations- und Studienmaterialien*, (Institut für Marxismus-Leninismus an der Technischen Hochschule für Chemie, Leuna-Merseburg), A ser. A *Lehrmaterialien*, part 4 (1960), p. 13.

[29] The prosecution in the Farben Case would have strengthened their argument if they could have found evidence of such deliberations by the Farben executives. Possibly the records were destroyed, but, even more likely, such illegal considerations as rearmament were discussed — if at all — off the record. Wolfgang Birkenfeld, in "Leuna, 1933", *Tradition*, viii (1963), pp. 107-8 n., finds a "surprising" instance of the direct interest of the German Defence Ministry in the manufacture of synthetic gasoline by the process of Friedrich Bergius in 1925. The Bergius process was acquired by Farben in 1926, but Birkenfeld does not believe that Farben followed up the discussions.

[30] *Die Katalytische Druckhydrierung*, p. 31.

by more fully utilizing these facilities, he would not only reduce the unit cost of fixed nitrogen but he could hydrogenate coal more cheaply. Brown coal was used to supply the heat necessary for the nitrogen fixation and methanol processes, and the capacity for generating this at Leuna could be more fully utilized by the new process. Furthermore, the intention to use brown coal as the basic hydrocarbon source for the production of synthetic gasoline would ensure fuller utilization of the coal handling and storage facilities, as well as the mining machinery. All of this was vital in an industry which, according to Bosch, made a profit from the utilization of only the last ten per cent of its production facilities.[31] This reasoning became more compelling as the late 1920s brought a more competitive nitrogen market.[32]

Bosch's leadership in the nitrogen fixation project and the analogy he saw between the great challenge of coal hydrogenation and the earlier project also led him to his decision. He was, after all, one of those who had known the exhilaration of success, who had acquired the creative potential and the professional characteristics of the hydrogenation specialists. In a few years, when the synthetic gasoline project threatened to end in humiliating failure, his deep commitment and the analogy he saw with the earlier and successful effort sustained him.[33]

For I. G. Farben to develop coal hydrogenation and to maintain other research and development, the capital of the enterprise had to be increased by 250 million marks in 1928. The investment in synthetic gasoline between 1926 and 1932 has been estimated as 100 million marks.[34] This exerted heavy pressure upon I. G. Farben,

[31] A lecture by Bosch on "Die Produktions- und Absatzverhältnisse der I. G. Farbenindustrie Aktiengesellschaft, Frankfurt a. Main", delivered 3 December 1928, and expanded 7 May 1930, p. 112: BASF *Firmenarchiv*, Ludwigshafen.

[32] "Die Entwicklung und wirtschaftliche Bedeutung der Chemie für Deutschland", anon. typescript, BASF *Firmenarchiv*. The increase in production of fixed nitrogen throughout the world and the competition on the world market brought a world nitrogen combine with quota agreements between 1929 and 1930. I. G. Farben as the world's leading producer played a leading rôle in these negotiations culminating in the *Convention de l'Industrie de L'Azote*. This constraint on production coupled with the decline in nitrogen fertilizer sales in Germany closed down a part of I. G. Farben's nitrogen fixation plant. As early as 1923 Bosch had foreseen such a situation and had ordered development of new processes to use this capacity: Carl Krauch, Affidavit, No. NI-6524, Nuremberg Military Tribunals; and Holdermann, *Bosch*, pp. 254-5.

[33] Holdermann, *Bosch*, pp. 263-4.

[34] Holdermann, *Bosch*, p. 234. I. G. Farben's expenditure on research and development between the wars was highest during the years 1927-29; this resulted in large part from hydrogenation research and development. Fritz Ter Meer, *Die I. G. Farben Industriegesellschaft: Ihre Entstehung, Entwicklung und Bedeutung* (Dusseldorf, Econ-Verlag, 1953), p. 110. Lutz Graf Schwerin von Krosigk, *Die Grosse Zeit des Feuers* (Tübingen, Rainer Wunderlich, 1958), ii, p. 587. (von Krosigk was German Finance Minister, 1932-45.)

Bosch and the chemists and engineers involved in the development of the process. Construction time, a costly interval in which the applied capital was not productive, created a sense of urgency. Failure of the process would threaten the existence of the entire enterprise and this created a driving determination. With so much at stake, Bosch and his advisers had not only to succeed in solving technological problems; they also had to be ready to establish an economic and political environment favourable to the product. The economic and political power of a mammoth industrial enterprise would later be used to reinforce its technological advance.

In the meantime, Farben's emphasis was upon technological problems. Matthias Pier was outstandingly successful in discovering a new catalyst which spurred and directed the reactions involved in coal hydrogenation.[35] In the laboratory in 1925 Pier obtained a good quality gasoline from coal, coal tar, and crude oil. 1926 brought such advances that Frank A. Howard, head of research and development for Standard Oil of New Jersey, after inspecting the laboratories and test facilities at Ludwigshafen, immediately wrote to the president of Jersey Standard that the hydrogenation process was "tremendously significant — perhaps more than any chemical factor ever introduced into the oil industry".[36]

In September 1926, the plan to construct a plant with an annual capacity of 100,000 tons at Leuna was publicly announced. Under the direction of Carl Krauch and with the technical leadership of Pier and his staff, construction at Leuna proceeded rapidly. At the time of greatest activity, over 13,500 workers from many parts of Germany were employed. Demand from Leuna stimulated the production of special material and equipment in Germany's steel and machinery industry and other areas of the economy. Leuna was front-edge technology drawing along related technologies.

By April 1927, contact ovens for the new process were in use at Leuna. From successful small-scale operations Bosch, probably encouraged by trouble-free methanol production, had taken a great and risky leap forward to full-scale. Unlike methanol, however, coal hydrogenation on the full-scale level brought numerous and "enormous" technological problems which the chemists and engineers

[35] For a discussion by Pier of the problems of discovering the most suitable catalyst, see C. Krauch und M. Pier, "Kohleveredelung und Katalytische Druckhydrierung", *Zeitschrift für angewandte Chemie*, xliv (1931), pp. 953-5.

[36] Frank Howard, *Buna Rubber: The Birth of an Industry* (New York, D. Van Nostrand, 1947), p. 17. The process was licensed to Standard Oil of New Jersey for increasing the gasoline yield from the heavy end of the petroleum molecular range.

were slow to solve. The greater complexity of the raw materials (brown coal and coal tar) used in the process was a prime reason for the difficulties.[37] These raised costs tremendously and threatened to bring the entire process into disrepute.[38]

In public statements I. G. Farben acknowledged difficulties in 1927, but Bosch insisted upon the analogy with the successful ammonia process.[39] A year later Farben claimed that, having overcome customary difficulties, production of high quality gasoline was rising steadily and that the goal of 100,000 tons would be reached during the year. Furthermore, improvements in the process made it likely that production could be doubled in 1929 without additional plants. Bosch hoped that large-scale production would bring profits by the end of 1928.[40] In 1929, however, Farben could report a production rate of only about 48,000 tons.[41] Even after production reached 70,000 tons annually in November 1929, prospects were in fact gloomy because of unexpected costs.

The board of management, some of whom were not as committed to the new field as Bosch, requested a progress and prognostication report in 1929. Carl Duisberg, formerly chairman of management at *Farbenfabriken Bayer A. G.*, Leverkusen, before becoming chairman of I. G. Farben's board of directors *(Aufsichtsrat)*, favoured giving up production of gasoline. Because of rising development and construction costs and falling gasoline prices, the report predicted a need of 400 million marks for further research and development, and thus it advised a moratorium.[42] Bosch and his supporters, including Krauch, avoided the shutdown however, by stressing the interrelationships of the technology at Leuna. If coal and tar hydrogenation were abandoned, then the cost of producing fixed nitrogen would

[37] Carl Bosch explained these development problems in detail in "Probleme Grosstechnischer Hydrierungs-Verfahren", a lecture delivered for the Norwegian Academy of Science in Oslo for the Fridtjof Nansens Fond, Oslo, 1933 (BASF *Firmenarchiv*). See also, *Die Katalytische Druckhydrierung*, p. 18; and M. Pier, "Kohle — Oel — Benzin", in *Erdoel und Kohle* (vereinigt mit *Erdoel und Teer*), xii (1935). The function of the catalysts was more complicated than in the other hydrogenation processes, and three substances had to be hydrogenated simultaneously (oxygen, nitrogen and sulphur).

[38] Holdermann, *Bosch*, p. 264.

[39] *Frankfurter Zeitung*, 3 June 1927.

[40] *Neue Mannheimer Zeitung*, 24 May 1928; *Frankfurter Zeitung*, 25 May 1928.

[41] Report of I. G. Farben for Annual Meeting, 14 June 1929: BASF *Firmenarchiv*.

[42] The report was prepared by Friedrich Jaehne, an engineer and member of the management board of I. G. Farben. See testimony of Jaehne in Doc. No. NI-6765, Nuremberg Military Tribunals. Carl Krauch stated that Carl Duisberg, chairman of the board of directors *(Aufsichtsrat)*, and his followers wanted to close down Leuna: Affidavit NI-6524.

rise. The supporters of Leuna also pointed out that fixed costs on the heavy investment at Leuna would continue even if the existing facilities were inoperative. Bosch and his supporters further noted that the abandonment of the activity would only intensify the economic problems of the régime of Chancellor Brüning, in whom Bosch had much confidence. The ultimate decision was to continue operations in expectation of weathering the crisis.[43]

Conceivably, Bosch and others favouring continuation of the Leuna project anticipated, in 1929, German rearmament and a related need for synthetic gasoline. Georg Thomas, later General, of the Army Ordnance Office *(Heereswaffenamt)* had prepared a memorandum a year earlier urging that the army encourage and, if necessary, financially support the development of raw material not available in Germany, such as "*Leunabenzin*".[44] Thomas, an early and persistent advocate of armament in depth *("Tiefenrüstung")*, also recalls efforts of his office in the late 1920s to enlist secretly the support of leading industrialists in preparing rearmament plans. Thomas, however, states that because of lack of government support and interest in the army at this early date in "*Tiefenrüstung*", his efforts were small-scale and the results slight.[45] In view of I. G. Farben's substantial investment in Leuna and the practical attitude of corporation business managers, Farben's decision in 1929, much as in 1926, would hardly have turned upon the small-scale efforts of an army planning group operating in secret on illegal rearmament under an unsympathetic army high command and government.

It is more likely, however, that Bosch and other Farben executives favouring continuation of the project were depending upon the government's commitment to the development of domestic raw materials to aid in the balance of payments. This was needed in 1929 more than in 1926. In 1926 when the decision to embark upon the project was made, the world's supply of natural petroleum seemed to some experts near exhaustion, but in the years immediately following rich, deep fields were found in the United States and elsewhere, and by 1930 the outlook was sanguine[46] — sanguine that is for crude oil interests, but not for Farben which could no longer count on the

[43] Holdermann, *Bosch*, pp. 263-5.

[44] Georg Thomas, *Geschichte der deutschen Wehr- und Rüstungswirtschaft (1918-1943)*, ed. Wolfgang Birkenfeld (Boppard/Rhein, 1966), pp. 494-5. (The document, dated 22 Nov. 1928, is reprinted, pp. 488 ff.) Hereafter cited as Thomas, *Rüstungswirtschaft*.

[45] *Ibid.*, pp. 59-60.

[46] On crude oil production in the twenties see Harold Williamson *et al*, *The American Petroleum Industry . . . 1899-1959*, pp. 302-7.

probability that a shortage would force up the price of natural petroleum and create market conditions favourable for the synthetic product. Farben's hopes of competing on an open world market were lessened and the company looked more to a protected internal market. As early as 1927 the government had shown its solicitude by giving Leuna gasoline a favourable freight rate on the national railroad and then lowering the petroleum tax in favour of Farben. Not only did Farben look to the government, it also made private arrangements to obtain a protected internal market.[47] In a contract negotiated with Standard Oil of New Jersey in 1929 the German market was left to Farben while Standard acquired rights to hydrogenation elsewhere. Standard Oil could use hydrogenation to increase the gasoline yield of crude petroleum.[48]

In 1930-31 Leuna achieved the goal of a 100,000 ton annual production rate but at the high cost of 40-50 pfennigs per litre.[49] Despite continuing difficulties, Bosch, the chemists, and the chemical engineers could consider the new plant at Leuna a technological achievement. In the meantime, however, the economic environment had changed so dramatically that it was no longer favourable for the technology. The onset of the depression had brought a sharp decline in the price of gasoline on the world market. In 1925 when Leuna was projected, the price of American export gasoline was about seventeen pfennigs per litre at North Sea ports. During 1929 the price had remained at about eleven pfennigs per litre (f.o.b. Gulf). Then in February 1930 the descent began, and by the end of the year the world market price had fallen to seven pfennigs; in 1931 the drop continued until it stabilized at about five.[50] When assuming future world market conditions to establish a price for Leuna gasoline, Farben had anticipated 20 pfennigs per litre to be competitive.

An unforeseen economic catastrophe and an unprecedentedly large capital investment placed I. G. Farben in a vulnerable situation. Bosch, Pier, Krauch, and others at BASF and I. G. Farben had applied knowledge and capital to create a new industry; now the men and the enterprise had a vested interest in a white elephant. The prospects were grim unless they could either wait out the depression or create an environment in which white elephants could flourish.

Coal hydrogenation needed an environment similar to that in

[47] Wolfgang Birkenfeld, "Leuna, 1933", *Tradition*, viii (1963), p. 99.
[48] Frank Howard, *Buna Rubber . . .* , *op. cit.*, pp. 27-32.
[49] Doc. No. NI-6767 (Krauch), Nuremberg Military Tribunals.
[50] Carl Bosch, "Erdöl und synthetisches Benzin", *Petroleum*, xxix (1933), p. 7.

which nitrogen fixation had first flourished. The economy of the war had been autarkic, and the producers of synthetics had not been in competition with imported natural products. The cost of research and development, the salaries of scientists and engineers, could be included in a price that did not need to be competitive with the price of materials taken from nature by cheap colonial labour. This had been the environment in which nitrogen fixation in its young and vulnerable years had survived; now coal hydrogenation needed a similar environment — at least until time brought a reduction of costs through the improvement of processes and the amortization of research and development costs. The firm sought help from Brüning.

The use of political power to create a more favourable environment offered a way out. As the depths of the depression were approached, the government could not ignore the distress of an industrial giant whose interests permeated the economy. Furthermore, the I. G. Farben programme of synthetics had saved foreign exchange and promised to save more as the shortage became increasingly severe. Earlier, Foreign Minister Gustav Stresemann had said that without I. G. Farben and without coal he had no foreign policy.[51] Not only were there many objective grounds for I. G. Farben to expect support, but personal contact was established by the close association of Bosch and Chancellor Brüning. Bosch had released Professor Hermann Warmbold from the managing board of Farben so that he might become Minister of Economics in Brüning's cabinet.[52]

Support from the government came in the form of a substantial increase in customs duties on imported gasoline. In 1929-30, before Brüning, the import duties had been four pfennigs, but this was of little help when Leuna costs were 40-50 pfennigs and sale prices were set at 30-35 pfennigs. During the tenure of the Brüning government (March 1930-May 1932) the customs duty was increased to 16 pfennigs per liter, the highest gasoline duty in Europe. Even so Farben would only have had a slight price advantage, if it had achieved the original goal of 20 pfennigs production cost.[53] In 1932 as the Brüning era closed, I. G. Farben was negotiating for new

[51] Krauch, direct examination, 12 Jan. 1948, Nuremberg Military Tribunals. According to Richard Sasuly, *I. G. Farben* (New York, Boni and Gaer, 1947), p. 82, the remark was made in 1927.

[52] Holdermann, *Bosch*, p. 168.

[53] Carl Bosch, "Erdöl und synthetisches Benzin", *Petroleum*, xxix (1933), p. 7; "Die Hydrierung und ihre wirtschaftliche Bedeutung", *Petroleum*, xxvii (1931), p. 8. Interrogation of Carl Krauch, 16 April 1947, NI-6767, Nuremberg Military Tribunals.

guarantees from the government.[54] The current level of import duties had already aroused adverse German public opinion. Increased support from a Weimar government was problematical.

In November 1932, after the Brüning government fell and when the von Papen régime was unable to gain popular support, I. G. Farben sought to clarify the position of the National Socialist party on synthetic gasoline, the largest single party in the *Reichstag* and a party that might form a new government. Heinrich Bütefisch and Heinrich Gattineau of Farben obtained at the request of Bosch an interview with Adolf Hitler. Bütefisch was a chemist who headed the Leuna works and Gattineau was in Farben's public relations department. Rudolf Hess and Professor Karl Haushofer arranged the interview which took place in Munich. A year earlier Gattineau had written to Haushofer asking him to use his influence with the National Socialists to stop publication of articles characterizing Farben as an instrument of international finance capital represented by the "Jew Warburg". The article immediately in question accused Farben, it is ironic to note, of neglecting the needs of Germany by failing to develop processes like the Haber-Bosch. Gattineau reminded Haushofer that Farben had been created by Christian self-made men, especially scientists and engineers.[55]

The prosecution at the Nuremberg trial of the Farben executives attached great importance to the Munich meeting in 1932, arguing that it created an alliance between Hitler and Farben based on their mutual interest in gasoline synthesis. Hitler, according to the prosecution, saw the possibility of using the synthetic product to free Germany from dependence upon imports and of its furthering his planning and preparation to wage wars of aggression. Farben, the prosecution continued, seized upon this support to avoid shutting down Leuna; "doubts within Farben immediately disappeared, and the synthetic gasoline programme was carried on and expanded".[56] The defence countered that Farben arranged the meeting to stop Nazi

[54] Krauch testimony *Trials of the War Criminals . . .*, vii, p. 610; Wolfgang Birkenfeld, *Der synthetische Treibstoff, 1933-1945: Ein Beitrag zur nationalsozialistischen Wirtschafts- und Rüstungspolitik* (Göttingen, Musterschmidt, 1964), p. 18.

[55] The affidavit of Heinrich Gattineau, Document NI-8788, Nuremburg Military Tribunals, discusses the 1932 meeting. Gattineau to Haushofer, 6 June 1931, and a copy of the article are in Haushofer Papers microfilm at the National Archives (T253-7).

[56] The prosecution's positions on the 1932 meeting, the campaign contribution, and synthetic gasoline are summarized in the opening statement for the prosecution, *Trials of the War Criminals . . .*, vii, pp. 119-24. Arthur Schweitzer, *Big Business in the Third Reich* (Bloomington, Indiana University, 1964), p. 102, believes that Hitler assured Bütefisch and Gattineau that he would

(cont. on p. 125)

press attacks upon the protective tariff and that similar meetings were held with other press authorities. Generally the hostile press had argued that the tariff discouraged the purchase of gasoline and frustrated the growth of the German automobile industry.[57] According to the defence, Gattineau and Bütefisch pointed out the advantages of Germany having a domestic supply of gasoline. Hitler, the defence continued, saw these advantages and agreed to end the press attacks. According to the defence there were no other agreements.[58]

Taking into account the arguments of both the defence and the prosecution it is reasonable to conclude that under the pressure of saving the synthetic project the Farben emissaries hoped not only to stop press attacks but also to ascertain and influence the National Socialist attitude towards a continuation of tariffs and perhaps the increase of governmental support.[59] Since the Nazis were the

(*note* 56 *cont.*)
actively support the production of synthetic gasoline and that I. G. Farben thereby acquired an economic interest in the installation of the Hitler government. He stresses the heavy campaign contribution of I. G. Farben to the Nazis in February 1933. Richard Sasuly, *I. G. Farben*, p. 110, describes the results of the 1932 meeting similarly. Eberhard Czichon in *Wer verhalf Hitler zur Macht* (Köln, Pahl-Rugenstein Verlag, 1967), pp. 39, 49-50, is of the opinion that Farben found in National Socialism the way to save the synthetic gasoline programme, and as a result had the interview and made the campaign contribution. He believes that it was no accident that the interview and the contribution came about the time that industrialists who had been supporting von Papen abandoned hope that he could form an effective government and about the time they moved to support the *Keppler-Kreis* of industrialists who advocated that Hitler become chancellor and embark upon a programme of autarky and rearmament.

[57] Krauch believed the strong press attacks between 1930 and 1932 were probably "guided by the automobile industry": Doc. No. NI-6767, Nuremberg Military Tribunals. The National Socialist daily, *Völkischer Beobachter*, usually had several columns in each issue on economic affairs. Despite ample opportunity to discuss tariffs and synthetic gasoline, no mention was made of the relationship. The backward and stagnant condition of the German automobile industry was often lamented, but the chief cause was thought to be the registration tax on the automobile. The high tariff on gasoline was only occasionally mentioned and then even justified by the protection it gave to German producers (neither synthetic gasoline nor Farben was mentioned, however): *Völkischer Beobachter*, 30 June, 3 Nov. and 20/21 Nov. 1932. Wolfgang Birkenfeld, author of *Der synthetische Treibstoff*, reports that press attacks in other Nazi publications cited by the defence were more against giant industrial firms in general than against Farben, synthetic gasoline, and the tariff: letter to the author, 31 August 1965. Rather than being concerned about Nazi opposition, Farben may have seen the possibility of their support because of their attitude.

[58] Interrogation of Bütefisch, Doc. No. NI-8637; and closing brief for defence of Bütefisch, p. 10, Nuremberg Military Tribunals.

[59] The most relevant documents from the Nuremberg Military Tribunals are: NI-8788; NI-8637; NI-4833; NI-6767; NI-6765; NI-6766; NI-14304; the closing brief of the defence for Bütefisch; and the testimony of Bütefisch and Gattineau on the subject of the 1932 meeting. The author's interpretation of the meeting and contribution is based on these.

largest party in the *Reichstag* and because they possibly might form a government, Farben had to face this reality and safeguard against the eventuality in order to protect synthetic gasoline; to safeguard, however, was not necessarily identical with conspiring to bring about the event.

The interview may well have persuaded Hitler to give the synthetic gasoline project the support necessary for survival. He certainly advocated the development of the road transport system and national economic self-sufficiency. His subsequent support of the Volkswagen project and his early inauguration of the *Autobahn* system followed from his commitment to motorization.[60] As early as 1927 he had told industrialists that he advocated economic self-sufficiency.[61] Before the discussions with Gattineau and Bütefisch, Hitler may have accepted the contention of the automobile industry that the high tariffs protecting Farben hindered the growth of the automobile industry. After the interview he may have seen the opportunity to combine his plans for motorization and for autarky. Assuming he had already decided to rearm Germany, the survival of Leuna, the development of road transport, and autarky were all consistent with such a decision.

Within the circle of his associates and advisers were those whose political and economic views prepared the way for his acceptance of the synthetic gasoline project. Gottfried Feder, the engineer turned political-economist, and Franz Lawaczek, Feder's associate in the Technology Bureau of the Nazis, wanted Hitler to use creative German technology to supplement her deficiences in natural resources.[62] Feder, according to Krauch, was interested in producing gasoline from coal. Haushofer, who was the most prominent of the influential geopoliticians in Nazi ranks and who helped arrange the 1932 meeting, probably recommended increased self-sufficiency in gasoline, for the German geopoliticians argued that a nation could not attain national integrity unless vital resources were within the national *Lebensraum*.

[60] Paul Kluke, "Hitler und das Volkswagenprojekt", *Vierteljahrshefte für Zeitgeschichte*, vii (October 1960), esp. pp. 341-5. See also Horst Handke, "Zur Rolle der Volkswagenpläne bei der faschistischen Kriegsvorbereitung", *Jahrbuch für Wirtschaftgeschichte*, 1962, Teil I. Handke has evidence of military influence on Volkswagen development as early as May 1934, pp. 28, 67.

[61] Henry Ashby Turner, Jr. "Hitler's Secret Pamphlet for Industrialists", *Journal of Modern History*, xl (1968), pp. 351, 372 (the pamphlet is reprinted). The Nazi position on autarky was occasionally stated in the *Völkischer Beobachter* in 1932. The policy recommended was self-sufficiency in vital materials, and trade for others: cf. 3 March and 10 August 1932.

[62] Doc. No. NI-6767, Nuremberg Military Tribunals.

Hitler's agreeing in 1932 that the survival of Leuna was in Germany's interest does not mean, however, that he had already decided to make synthetic gasoline a keystone in his economic programme, or in the rearmament of Germany. After the seizure of power in 1933, he supported for a time an ambitious project of Feder and others to build in Germany refineries and other facilities for processing crude oil. The oil, however, would have been imported. The merit of the plan was that it would have created many jobs in the German heavy-engineering industry which would build the facilities, and it would save foreign exchange because the crude was much less expensive than the refined product.[63] Later in 1933 when this plan was abandoned and an increase in Leuna gasoline ordered, this indicated that the régime, in favouring a capital-intensive project to a labour-intensive one, was placing economic self-sufficiency ahead of its unemployment programme.

If Hitler's advocacy of the Feder programme, even if only briefly, indicates that he had not decided in 1932 or early 1933 to depend upon Farben as a major source of gasoline, then he could not have conspired about rearmament with Gattineau and Bütefisch in the fall of 1932. Furthermore, the prior relations of Farben and the National Socialists were hardly a basis for the sharing of confidences. Carl Bosch was characterized as late as February 1933 as "a southwest German liberal known for being an opponent of the Nazis".[64] Gottfried Feder and others still in the party had consistently attacked very large concerns and trusts and advocated nationalization.[65]

Turning to 1933, the prosecution also offered as evidence of an alliance based on a common interest in Leuna gasoline, rearmament and territorial expansion by aggressive wars, a 400,000 Reichsmark campaign contribution made by Farben to the National Socialists on the eve of the *Reichstag* election of March 1933. The contribution followed a talk given by Hitler to industrialists on 20 February 1933. In his talk Hitler suggested the possibility of rearmament to his listeners, a Farben representative among them, when he said that the question of the restoration of the *Wehrmacht* would not be decided in Geneva but in Germany. His emphasis however, was upon the

[63] Wolfgang Birkenfeld, "Leuna, 1933", *loc. cit.*, pp. 101-2.

[64] George W. F. Hallgarten, "Hitler and German Heavy Industry, 1931-1933", *Journal of Economic History*, xii (1952), p. 245. Louis Lochner in *Tycoons and Tyrant: German Industry from Hitler to Adenauer* (Chicago, Henry Regnery, 1954) consistently portrays Bosch as anti-Nazi.

[65] Feder and other National Socialists holding radical economic or socialistic views were not rooted out of the party until the Röhm Purge in 1934. Dieter Petzina, *Autarkiepolitik im Dritten Reich: Der Nationalsozialistische Vierjahresplan* (Stuttgart, 1968), p. 22. Cited hereafter as Petzina, *Autarkiepolitik*.

necessary struggle against communism in Germany and the need for an orderly environment in Germany that would permit economic development and social harmony.[66] The oblique reference to rearmament would have stimulated a campaign contribution, if the conspiracy thesis is accepted, but the contribution can be more simply interpreted as a continuation of Farben's policy of some years' standing to make contributions to strong political parties in order to get political support. In 1926 Carl Duisberg, chairman of the board of directors *(Aufsichtsrat)* of Farben had urged German industry, especially electrical and chemical enterprises, to follow the lead of United States industry and become involved in parliamentary politics. Thus Farben established close relations with major political parties in the late 1920s, and often contributed to their funds.[67]

Later in 1933 however, when Farben and the National Socialist régime were negotiating a contract for synthetic gasoline, Farben executives could conclude from events and comments that Hitler intended rearmament. He had instructed cabinet officials to carry out their unemployment and other programmes with consideration of armament needs. Nor did he conceal from his generals his desire for economic rearmament and territorial expansion.[68] Yet Hitler was known to distort to achieve desired propaganda effects, and in his semi-secret talk of rearmament he may have been courting the support of army officers and those favouring rearmament. Doubts could also have been aroused by Hitler's frequent public protestations of his peaceful intentions. He did not vigorously push his plans for rearmament until the turn of the year 1933-4 after he had decided that France would not fight a preventive war to block such a move.[69] The practical attitude for Farben to have taken was that Hitler's public talk of motorization and *Autobahn* construction and private references to armament all promised a market for Leuna gasoline. The prosecution at Nuremberg could not prove, however, that the

[66] A report of Hitler's speech of 20 February 1933 to the industrialists, is reprinted in *Trials of the War Criminals . . .*, vii, pp. 557-61.

[67] H. Etzold, "Carl Duisberg", *Jahrbuch für Wirtschaftgeschichte*, 1966, part III, p. 213; Richard Sasuly, *I. G. Farben*, p. 66.

[68] Petzina, *Autarkiepolitik*, p. 20. Even on the level of an annual meeting of the German Society of Engineers *(Verein Deutscher Ingenieure)* as early as May 1933 spokesmen for the new régime stated publicly that engineers had to contribute to national defence. "Die Ingenieurtage am Bodensee", *Zeitschrift des Vereines Deutscher Ingenieure*, lxxvii, 8 July 1933, p. 726. This was soon stated more explicitly and in more detail: *ibid.*, 14 Oct. 1933, p. 1127.

[69] Gerhard Meinck, *Hitler und die deutsche Aufrüstung, 1933-37* (Wiesbaden, Steiner, 1959), pp. 17, 18, 85, and 86. Dieter Petzina, "Hauptprobleme der deutschen Wirtschaftspolitik 1932-1933", *Viertelsjahreshefte für Zeitgeschichte*, xv (1967), pp. 43-4.

régime at this time took Farben into its confidence and that both conspired to use Leuna gasoline in wars of aggression.[70]

Some historians, on the other hand, have asserted that Farben lusted for conquest in eastern Europe even before Hitler came to power and saw in him and his régime the opportunity to fulfil this objective.[71] A public speech made by Carl Duisberg in 1931 is offered as evidence, for in it he spoke of a single economic bloc from Bordeaux to Odessa. Such a bloc, it is argued, could have been achieved only by force. Whatever validity there may be in this interpretation (which ignores the faith of technocrats in rational economic arrangements even among political foes), Farben would not have been impelled towards Odessa by considerations forced upon her by the technological momentum built up and manifested by Leuna, for a move to the southeast would have meant natural oil for Germany. It can be argued, in contrast, that the vested interest in Leuna would lead Farben to shun and even forestall adventurous policies which would bring Germany supplies of crude oil and other raw materials for which Farben might supply substitutes.

After the March 1933 election Feder, representing the Ministry of Economics, and representatives of Farben discussed the synthetic gasoline programme. The details of the negotiations are not available, but the government wanted an increase of production at Leuna above the 100,000 ton capacity. Farben objected on the grounds that an increase would create technological problems resulting in higher costs which the market could not bear. The compromise agreement was formalized in the so-called Feder-Bosch contract of 14 December 1933.[72] The basic principle of the agreement was that the government would guarantee a sales price equal to the cost price as the production rate was expanded up to 350,000 tons

[70] The Nuremberg Tribunal found the twenty-three Farben executives not guilty of the charge, "Count One", that they had participated in the "planning, preparation, initiation, and waging of wars of aggression". The prosecution could not persuade the judges beyond reasonable doubt that the Farben executives had knowledge of Hitler's plans as late as 1939 to wage wars of aggression. *Trials of the War Criminals* . . . , viii, p. 1123. In the opinion and judgement of the Tribunal the defendants did contribute knowingly to the rearmament of Germany, but the Tribunal did not judge this a crime: p. 1114.

[71] H. Radandt, "Die IG-Farben und Südosteuropa bis 1938", *Jahrbuch für Wirtschaftgeschichte*, 1956, part III, pp. 150-2; Gisela Kahl, *op. cit.*, p. 12.

[72] The contract is reproduced in Doc. No. NI-881, Nuremberg Military Tribunals. For a discussion of its interpretation in practice, see Krauch Affidavit, Doc. No. NI-6524, Nuremberg Military Tribunals; Birkenfeld, *Treibstoff*, pp. 26-34.

of gasoline per year (by 31 December 1935). It also guaranteed a market for the gasoline.[73]

A harbinger of future developments was that the conversations and negotiations between I. G. Farben and the government took concrete form after the Air Ministry and War Ministry joined the discussion as interested parties.[74] Krauch had submitted a treatise on the German motor-fuel economy to the Air Ministry on 14 September 1933, discussing development of domestic supplies; representatives of the Army Ordnance Office joined in the discussion of it.[75] Krauch, and other Farben executives informed of the negotiations, probably then perceived the opportunities offered by the policies of the new régime to a company able to synthesize vital raw materials from German resources.

Farben had moved in 1932-33 from efforts, ostensibly in the interests of Germany's balance of payments, to protect Leuna by tariffs and other political-economic means that could be provided by a Weimar government, to efforts in the interests of motorization and autarky to protect Leuna with the support of the National Socialists. By the end of 1933, Farben was expanding the synthetic gasoline programme in alliance with a Nazi régime embarked upon a programme of rearmament. Thus the tactics shifted over the years but the strategy remained that of ensuring the survival of Leuna, a strategy consistent with the force of technological momentum.

Three years later the synthetic gasoline project was integrated into an armaments programme; a domestic supply of gasoline was thought a *sine qua non* of rearmament.[76] Leuna and new plants for the production of synthetic gasoline flourished in an environment of rearmament and autarky. When the war came, synthetic gasoline

[73] Wolfgang Birkenfeld in "Leuna, 1933", *op. cit.*, interprets the contract as evidence of the National Socialists' effort to solve firstly, the balance of payments problems which were worsened by gasoline imports, and secondly the unemployment problem. In this article, based on a thorough consideration of the defence in the Krauch Case, the author notes that in 1932 Farben sought a price-guarantee contract with a pre-Nazi government (pp. 100, 103).

[74] Karl Dietrich Bracher, Wolfgang Sauer, Gerhard Schulz, *Die Nationalsocialistische Machtergreifung* (Köln, Westdeutscher Verlag, 1960), pp. 819-20, 663.

[75] *Trials of the War Criminals* . . ., vii, pp. 571-3 (relevant documents are reprinted).

[76] Birkenfeld, *Treibstoff*, pp. 53-6. In the secret memorandum that Hitler prepared in August 1936, as a candid statement of the objectives of the Four Year Plan, he stated that a major problem to be solved by the Plan was not fuel for motorization and industrialization but fuel for waging war: Wilhelm Treue, "Hitler's Denkschrift zum Vierjahresplan 1936", *Vierteljahreshefte für Zeitgeschichte*, iii (1955), p. 208. (This does not establish his intent in 1933.)

proved critically important both for land warfare and for aviation.[77] Furthermore, with the inauguration of the Four Year Plan in 1936, the Nazis provided new creative opportunities. Krauch was loaned to the government by I. G. Farben to administer that part of the programme responsible for research and development in materials, and Hitler demanded the rapid replacement of imported materials, such as rubber, with synthetics or domestic materials. I. G. Farben's engineers and chemists played leading rôles in fulfilling the objectives of the programme. Through the programme Farben became more deeply involved with National Socialism.[78] Further studies might also reveal the force of technological momentum in bringing about this situation in 1936.

The history of hydrogenation in Germany between 1914 and 1933 reveals, in summary, a technology stimulated by war gathering a momentum carrying over into peacetime. The commitment of engineers, chemists, and managers experienced in the process, and of the corporation heavily invested in it, contributed to this momentum. The product of the wartime hydrogenation process was applied to peaceful purposes, but this did not entirely absorb the creativity of the engineers and chemists looking for new applications of the challenging technology they had mastered. They found their opportunity in the most demanding of the hydrogenation processes, the synthesis of gasoline from coal. The process had exciting prospects because Germany could overcome a natural handicap with a synthetic product of technology. Events took a tragic turn, however, with the coming of the depression which ruined the market. Then the technology, having gathered great force, hung heavily upon the corporation that developed it and thereby contributed to the

[77] In June 1944, the Eighth Air Force had as its prime strategic target the synthetic oil plants in central and eastern Germany, including Leuna. The bombing of these and other refineries, and the exclusion of the Germans from Ploesti resources brought the German fuel position to the point of catastrophe by September 1944. In early 1944 the output of the synthetic plants had been so large that the Germans viewed the fuel situation with optimism: *The Army Air Forces in World War II*, ed. W. F. Craven and J. L. Cate (Chicago, University of Chicago Press, 1951), iii, pp. 172, 281, 303.

[78] *Trials of the War Criminals . . .*, vii, pp. 21-5. The record of the trial, Case 6 (the Krauch Case), provides a history of I. G. Farben and its technology after 1933. The history of synthetic gasoline subsequent to the period covered in this paper can be found in Birkenfeld, *Treibstoff*, *op. cit.*; details of the four year plan in Petzina, *Autarkiepolitik*.

fateful decision of the vulnerable corporation to co-operate with an extremist political party.[79]

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[79] The question of the attitude of Farben executives toward Nazi ideology has not been explored in this paper; the technological factor seems a sufficient explanation for the decision to co-operate with the Nazis. Assuming that Bosch was the chief decision-maker, his attitude is of interest. Bosch, chairman of the managing board *(Vorstand)* of Farben until 1935, and then of the *Aufsichtsrat,* died before the Nuremberg trials, but he was often mentioned. He was frequently characterized by the defence as fundamentally anti-Nazi. Among those giving affidavits for the defence and maintaining this were Kurt Freiherr von Lersner, head of the German Peace Delegation to Versailles, and Hermann Buecher, chairman of the managing board of *Allgemeine Elektrizitätsgesellschaft* (1928-1946): Defence Documents, Nuremberg Military Tribunals. Buecher, a close friend of Bosch, stated that Bosch became obsessed in the late 1930s by the idea that he had unintentionally made Hitler's aggressive foreign policy possible by the development of nitrogen fixation, synthetic gasoline, and synthetic rubber. In his biography Holdermann develops the thesis that Bosch accepted the new régime without enthusiasm as long as he thought Hitler was primarily interested in motorization, full employment and highway construction, but that by 1934 he was disillusioned. For a critical view of Bosch and his rôle in technology and politics see Heinz Beike, "Zur Rolle von Fritz Haber und Carl Bosch in Politik und Gesellschaft", *Wissenschaftliche Zeitschrift der Technischen Hochschule für Chemie Leuna-Merseburg,* iii (1960/61), pp. 55-72.